Supplementary Materials for

Element Specific Hyperspectral X-ray Imaging

S. D. M. Jacques, C. K. Egan, M. D. Wilson, M. C. Veale, P. Seller and R. J. Cernik*.

*To whom the correspondence should be addressed. Email: B.Cernik@manchester.ac.uk

This PDF file includes:

Description of USB web-cam dongle

A description of the Treatment of Transmission Spectral Data

Supplementary Figures S1-S3

Table S1

Description of USB web-cam dongle

The USB web-cam dongle was purchased as part of an A65JW 2.4 GHz wireless web-cam from Maplin Electronics. Photographs (and radiograph) of the external and internal of the USB dongle are shown in figure S2, some components of which have been annotated. The high Z elements of these components are shown in table S1.

Table S1

Component	**High Z elements/phases contained within**
0402, 1206 Ceramic Capacitors	Barium Titanate
1206 high q Ceramic Capacitors	Zirconium Acetate
A106 Capacitor / Diode	Tantalum, Tantalum Oxide, Manganese Dioxide, all with Silver coating. Can contain contain neodymium, samarium and other rare earth oxides
6206A	Silver
A7125 2.4GHz Transceiver	Silver

Treatment of Transmission Spectral Data

The transmission spectra seen in figure 1 have been produced by treatment of the data using the Beer-Lambert relationship to arrive at optical:

$$-ln\left(\frac{I(E)}{I_0(E)}\right) = \mu(E)t \quad (1)$$

Where $I(E)$ is the incident recorded spectrum for each pixel after absorption through the sample. $I_0(E)$ is incident spectrum for each pixel without the sample in place. This was obtained from flat-field field images which were also used to correct for intensity variations across the fan beam. One should note that this is not sctrictly a true measure of $I_0(E)$ but rather a convolution with a detector response $R(E)$, accounting for the quantum efficiency of the detector (as a function of energy) as well as any charge trapping within the detector. This is also the case for $I(E)$. Nonetheless, transmission spectra still retain such features like absorption edges as highlighted in the main text. Deconvolution to obtain true $\mu(E)t$ is ill-posed and statistically noisy.

Figure S2A shows the spread of the data in the red, green and blue regions of figure 1D. These regions have limited spread and show many features. Thes features can be extracted by pattern decomposition from the treated and indeed the raw data, as illustrated in figure S2B. Figure S3 shows annotated versions of figures 1D-F and annotated photograph of one side of the PCB. The distribution of various elements determined by hyperspectral imaging correlates with the known positions of the components.

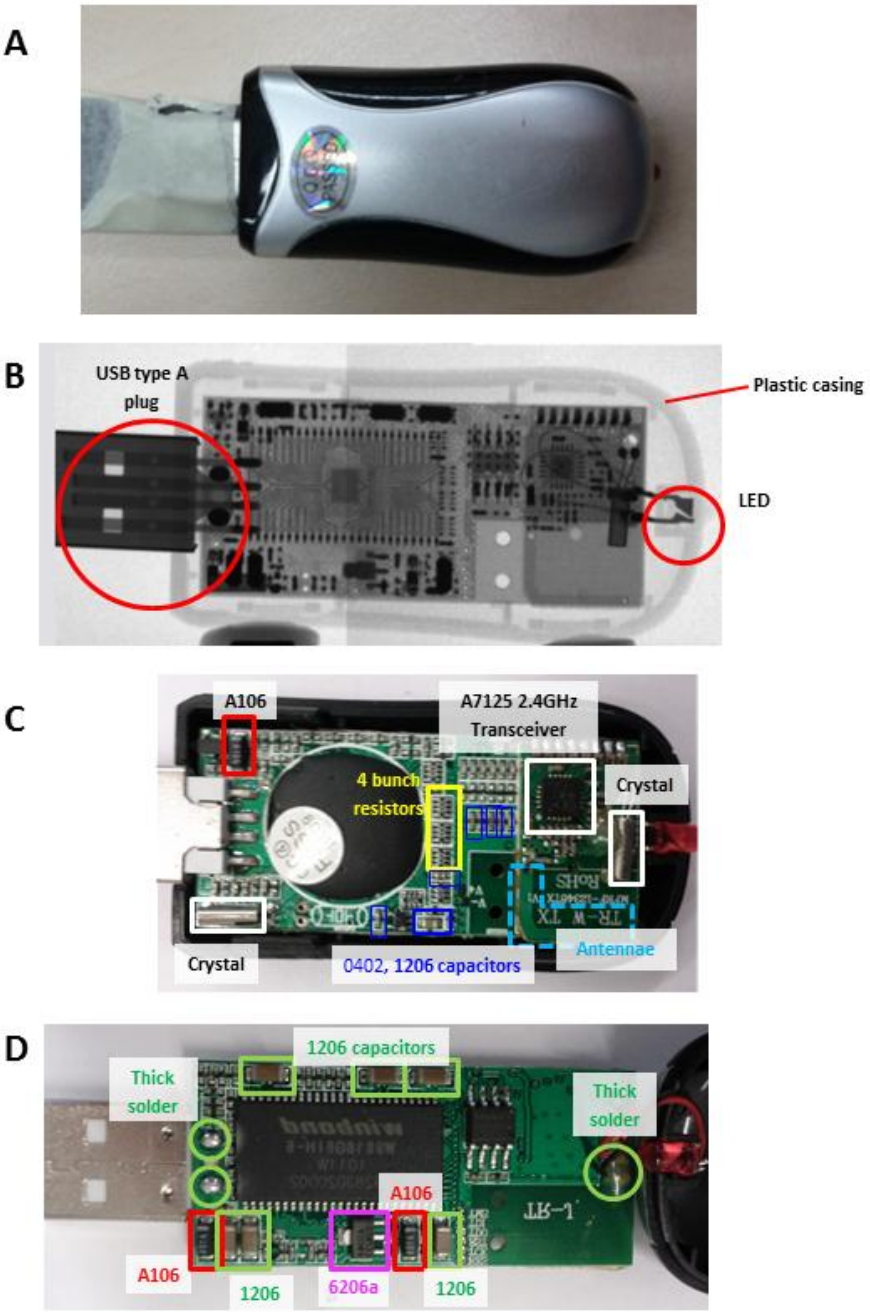

Figure S1 Annotated photographs and radiographs of USB dongle. *Maplin USB wireless data receiver as photograph as scanned (A), radiograph (B), and photographs as opened front (C) and back (C); the latter flipped for display purposes. The boxes, circles and associated labels indicate the positions and generic identities of particular components.*

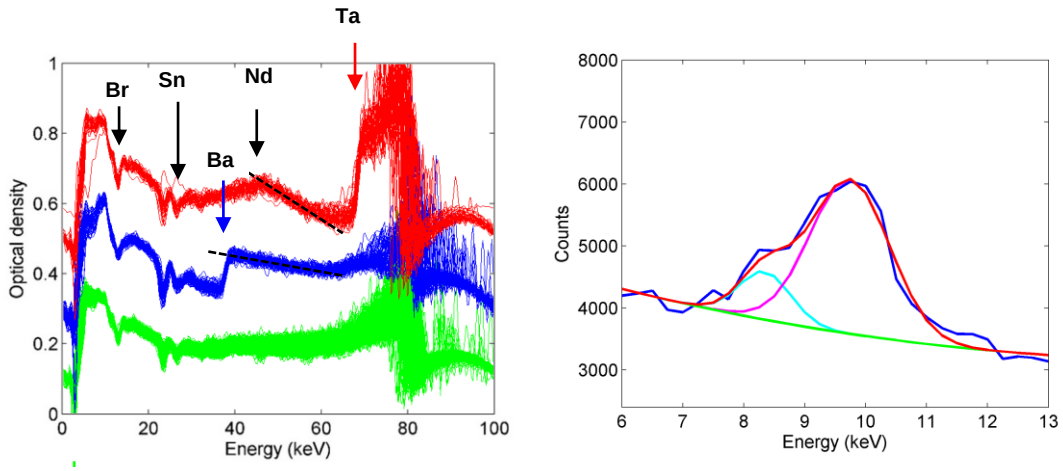

Figure S2 (*A) Spread of treated spectra in the red, green and blue regions from figure 1D. The spectra are coloured accordingly. For display purposes, a low band pass filter has been applied (removing the two lowest frequencies) and the red and blue spectra have each been offset by a constant on the y axis. The black arrows indicate the positions of various K-edges. The dotted lines indicate obvious linear/near-linear regions; such features and others can be extracted by pattern decomposition. (B) Example fit (red curve) of 2nd order polynomial (green curve) and two gaussians (cyan and magenta curves) to a single untreated spectra (blue curve). Such fits and others were made to the 86848 spectra that make up the image of the USB web-cam dongle, yielding images of the type presented in figures 1E and 1F.*

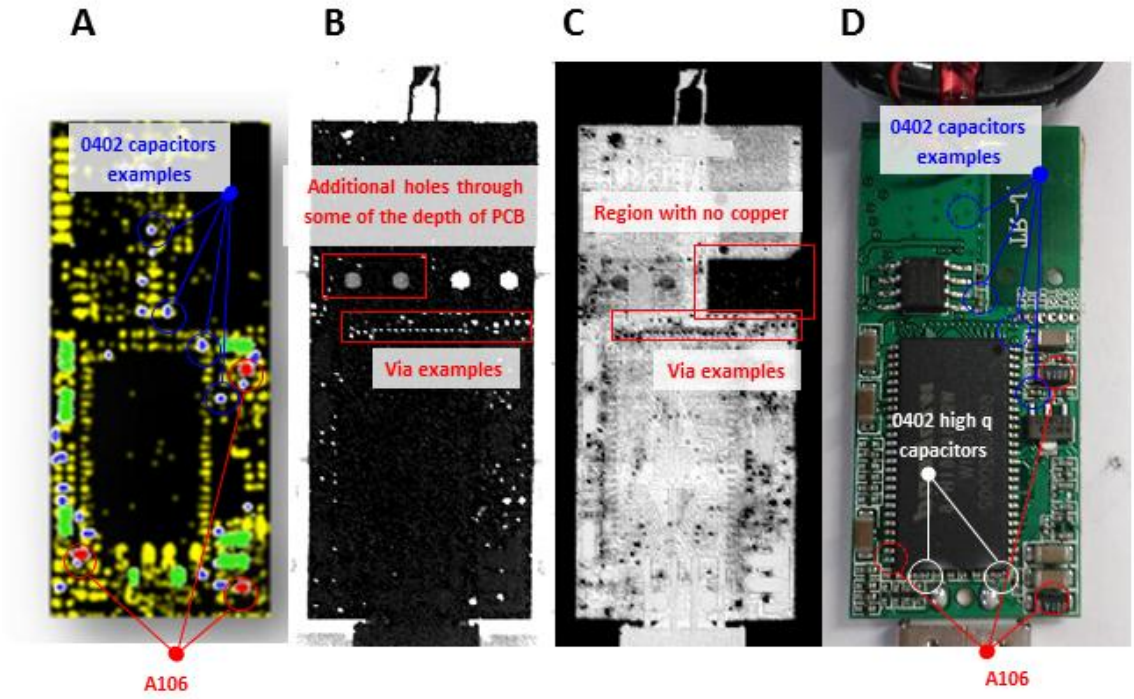

Figure S3 Annotated large versions of images found in figures 1D-F with comparison to photograph of PCB. *Dotted circles on the annotated photograph indicate that components feature on the opposite side of the PCB. There are several 0402 capacitors on the board, the circled are illustrated examples.*